GFDL Summer School [2012]

Introduction to NOAA/ GFDL Science

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OUTLINE OF THIS MORNING's PRESENTATION

- **Introduction to GFDL {Ramaswamy}**
- **Radiative Transfer {Ramaswamy}**
- **Solar Radiation {Ramaswamy}**
- **Longwave Radiation and Climate Applications {Dan Schwarzkopf}**
- **Climate Applications concluded {Ramaswamy}**
- **Questions/ Comments {Dan Schwarzkopf and Ramaswamy}**

NOAA/ GFDL Mission

GFDL's mission directly addresses the NOAA Strategic Goals

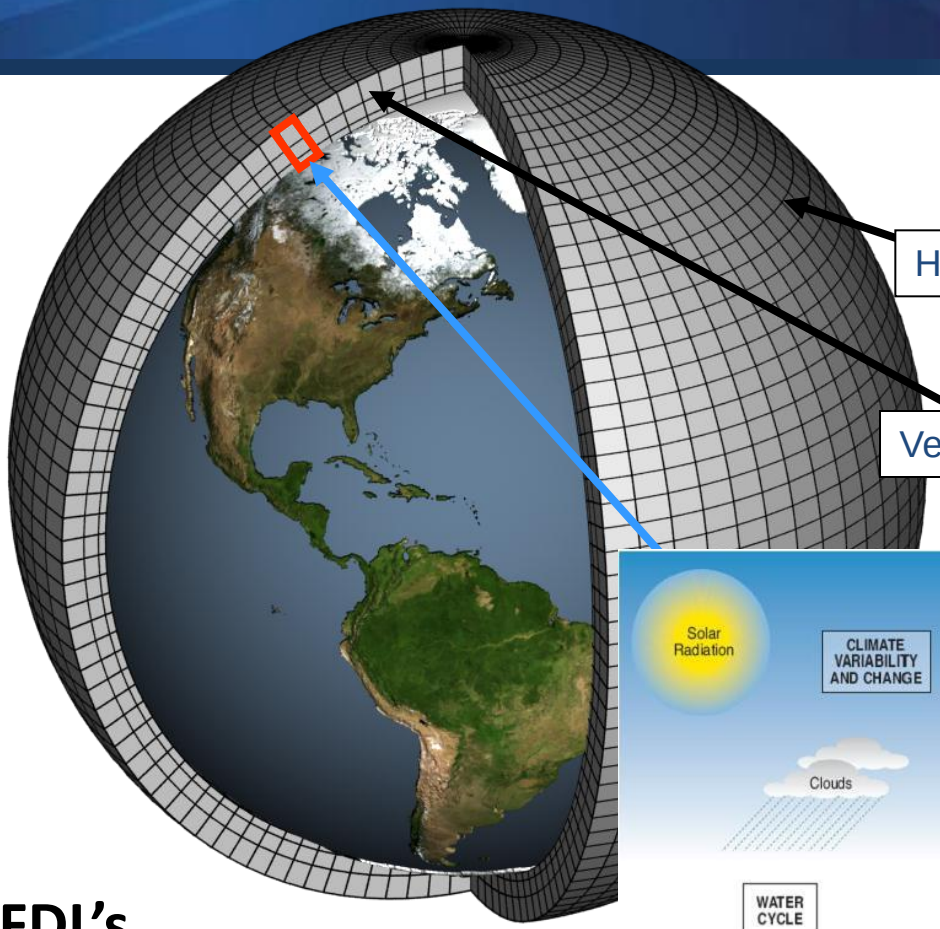
Be a world leader for the production of timely and reliable knowledge and assessments on natural climate variability and anthropogenic changes and in the development of the required earth system models.

Work cooperatively in NOAA to advance its expert assessments of changes in national and global climate through research, improved models, and products.

GFDL is one of the "high-end Climate Modeling Centers" called for in the US Global Change Research Program

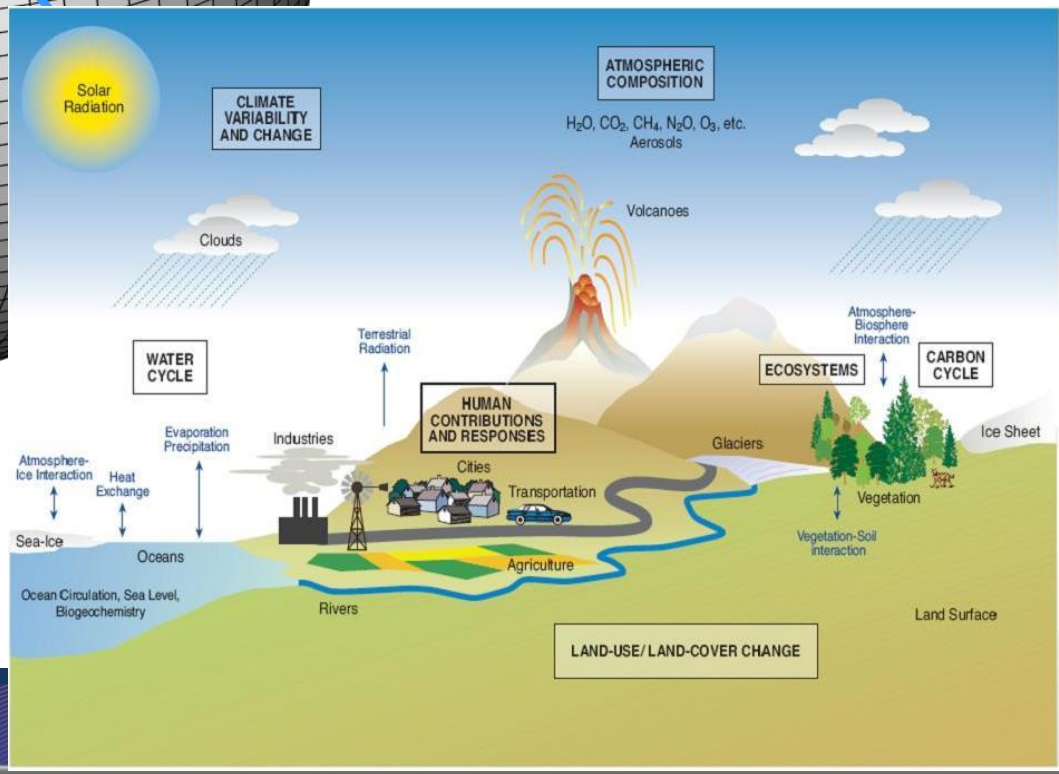
NOAA Cooperative Institute for Climate Science at Princeton University

Schematic Global Climate Model



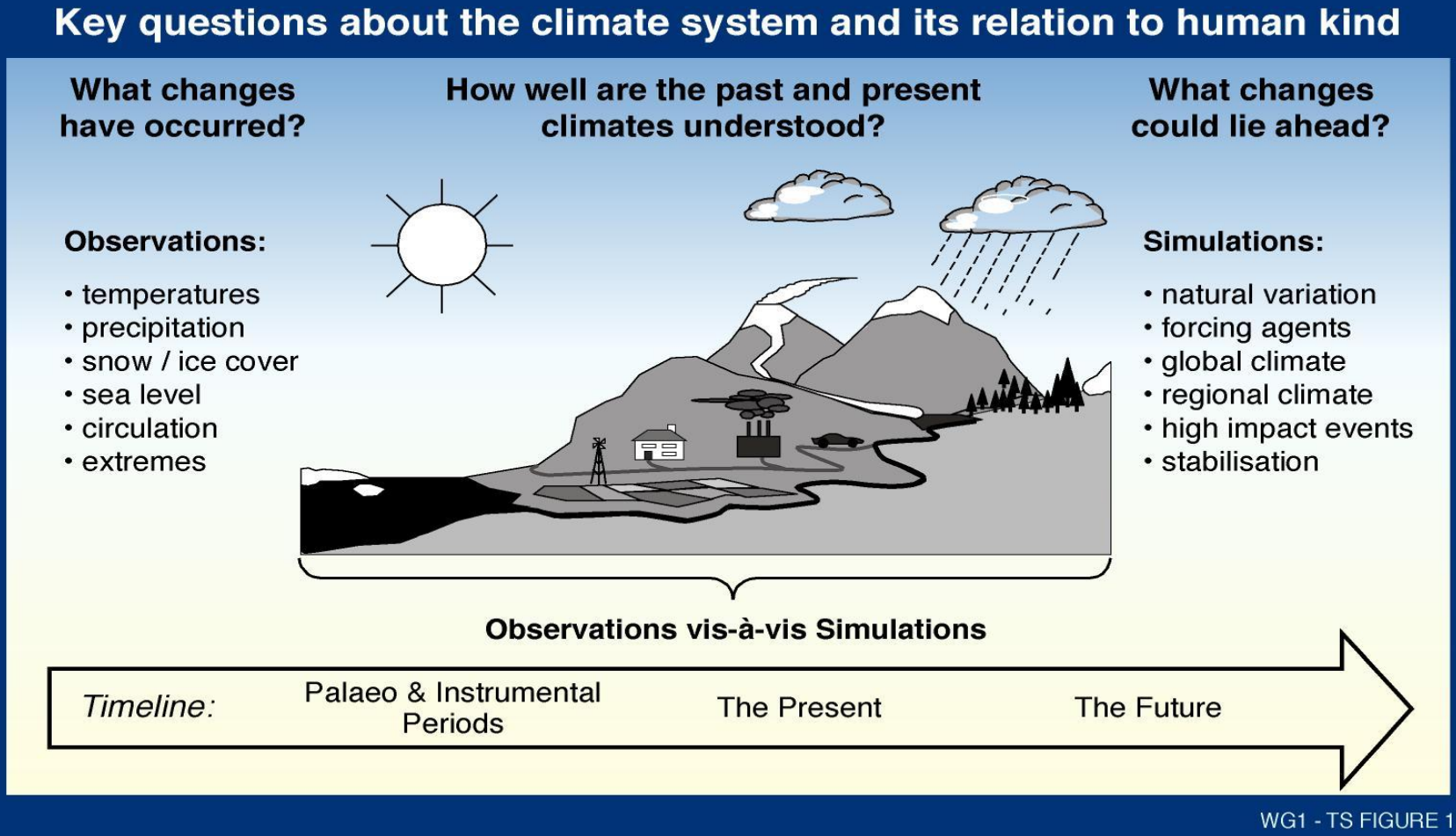
Horizontal Grid (Latitude-Longitude)

Vertical Grid (Height or Pressure)



NOAA/GFDL's CLIMATE and EARTH SYSTEM MODELING

Why are models critically needed?



Planning, Execution, Results, Lessons

→ *advancing the frontiers of climate science*

THEORY

Scientific literature

OBSERVATIONS

Papers, Assessments

KNOWLEDGE & UNDERSTANDING

MODEL DEVELOPMENT

```
if (diagts .and. eots) then
  do 1500 m=1,nt
    do 1490 k=1,km
      fx = cst(j)*dyt(j)*dzt(k)/(c2dtts*dtxcel(k))
      do 1480 i=2,imtm1
        boxfx          = fx*dxt(i)*fm(i,k,jc)
        sddt           = (ta(i,k,m)-t(i,k,jc,nm,m))*boxfx
        svar           = (ta(i,k,m)**2-t(i,k,jc,nm,m)**2)
                         *boxfx
        n              = 0
        termbt(k,1,m,n) = termbt(k,1,m,n) + sddt
        tvar(k,m,n)    = tvar(k,m,n)     + svar
        n      = nhreg*(mskvr(k)-1) + mskhr(i,j)
        if (n .gt. 0 .and. mskhr(i,j) .gt. 0) then
          termbt(k,1,m,n) = termbt(k,1,m,n) + sddt
          tvar(k,m,n)     = tvar(k,m,n)     + svar
```

WELL-DESIGNED MODEL EXPERIMENTS

ANALYSIS OF MODEL RESULTS

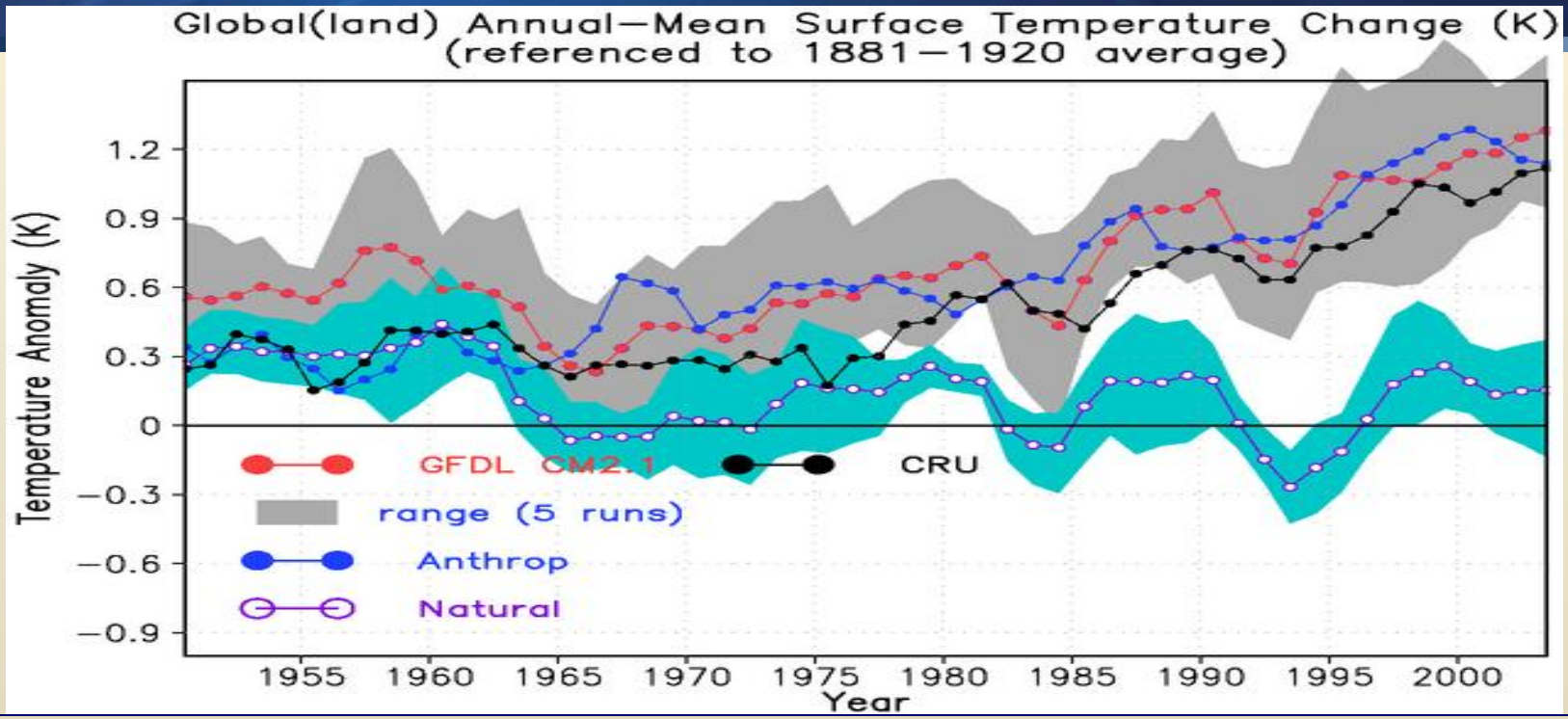
OBSERVATIONS

NOAA / GFDL MODELS: The Evolution

ADDRESSING KEY CLIMATE PROBLEMS

	1960's -1980's	1990's	2000's
Principal Modeling Accomplishments	"1st" series of Atmosphere-Ocean-Land Coupled Models		CM 2.0 & CM 2.1 Climate Models
	Nested-Grid Hurricane Model	Operational Implementation of Hurricane Forecast System	Novel Spatial Grids
	Experimental Numerical Weather Prediction Model		High-Spatial-Resolution Atmosphere Model
	"Benchmark" Radiation Codes	Flexible Modeling System (FMS)	Climate Change & Hurricane Modeling
	"SKYHI" Stratosphere Model	Global Stratospheric Ozone Depletion Model	Atmospheric Chemistry & Aerosol Processes
		Global Chemistry Transport Model	Ozone Depletion & Recovery Model
	Primitive Equation Global Ocean Models	Modular Ocean Model	Ocean Physical Processes; Isopycnal Ocean Model
		Cloud-Resolving Model	Dynamic Sea Ice Processes
	Limited Area Nonhydrostatic & Mesoscale Models	ZETAC Mesoscale Model	Land-Surface Processes; Biospheric Processes
			Earth Systems Model
			Ensemble Coupled Data Assimilation System
Participation in Major Scientific Projects/ Assessments	FGGE/GARP	WMO Stratospheric Ozone Assessment; IPCC Assessments	CCMVal Assessment; CCSP Assessments; NARCCAP Assessment; WCRP (CLIVAR, GEWEX, SPARC, CLIC)
Laboratory Directors	Dr. Joseph Smagorinsky, Founder of GFDL, 1955-1983	Dr. Isidoro Orlanski, Acting Director, 1983-1984; Dr. Jerry Mahlman, 1984-2000	Dr. N-C Lau, Acting Director, 2000-2001; Dr. Ants Leetmaa, 2001-2006; Dr. Ramaswamy, Acting Director, 2007-2008; Dr. V. Ramaswamy, 2008-Present

IPCC AR4 Simulations
Attribution to CO2, Other GREENHOUSE GASES and AEROSOLS



20th Century Global-mean Surface Temperature change

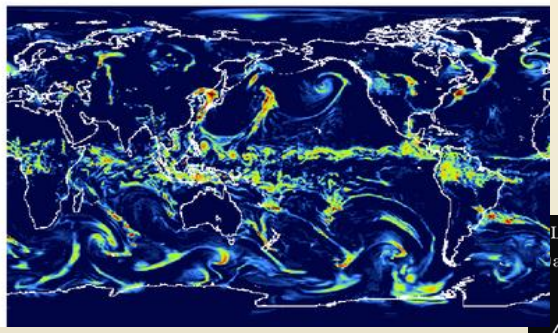
Total Anthropogenic → 0.8K

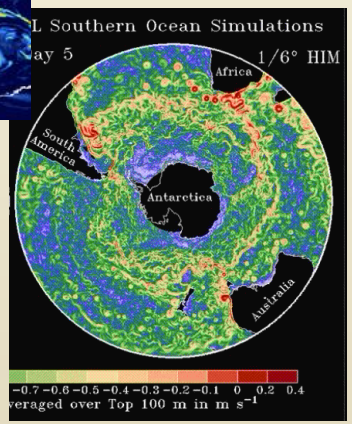
All Gases → 0.9K; CO2 only → 0.5K

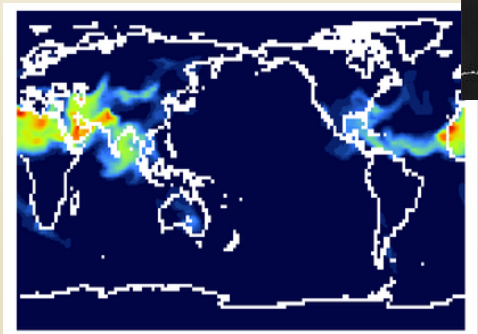
Anthro. Aerosols → - 0.2K

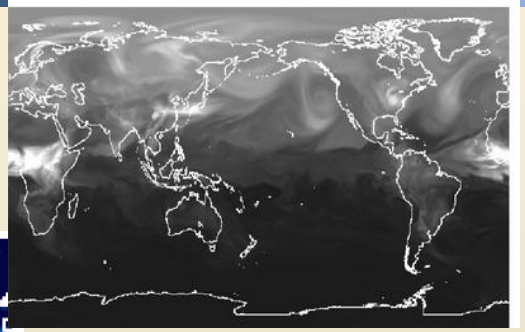
(BC+OC) → 0.2K; (Sulfate) → - 0.4K

Current NOAA/ GFDL Climate Modeling [IPCC AR5]



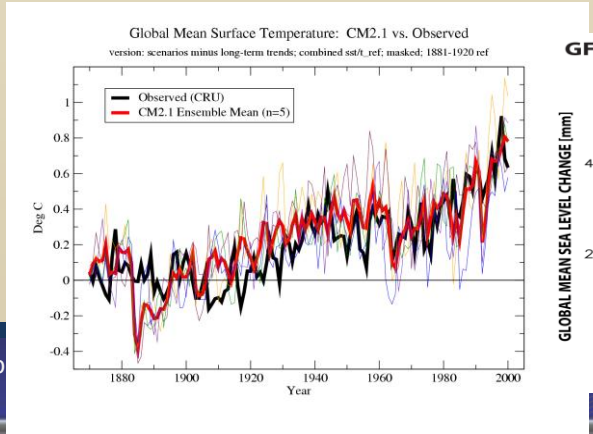


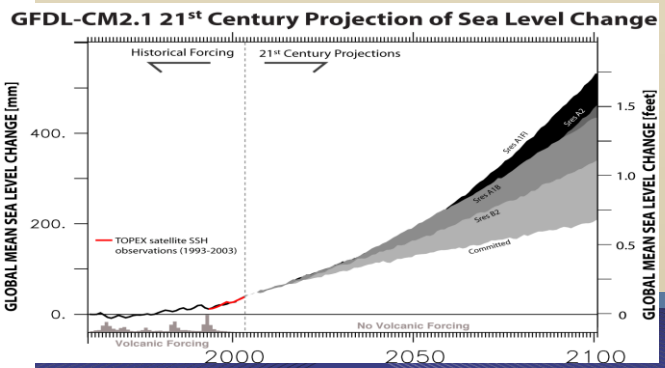




Resolution

Earth System Complexity





Current NOAA/ GFDL Climate Modeling

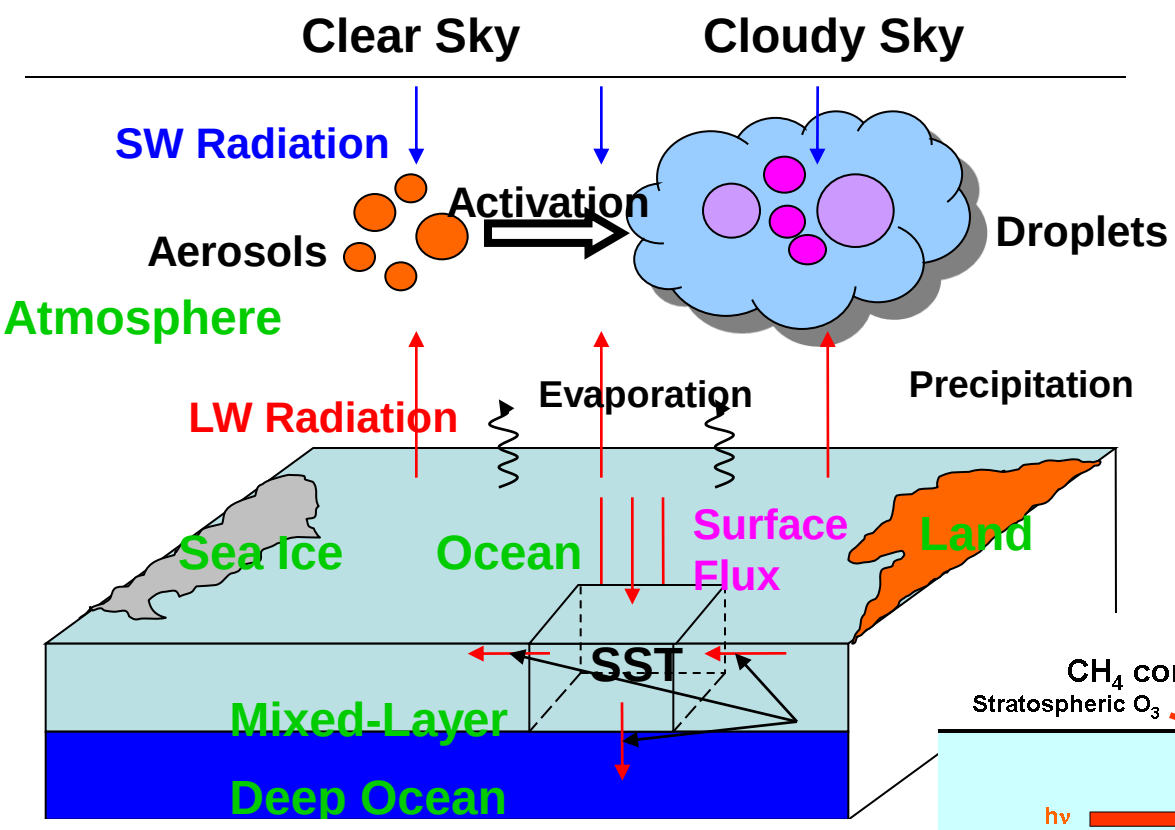
Contributions to CMIP5 and IPCC AR5 [Report in 2013]

Advancing the understanding of the climate system, leading to reliable global- to regional-scale projections and predictions:

1. **Role of pollutant particulates and other short-lived species compared to long-lived gases such as carbon dioxide.**
2. **Carbon and other biogeochemical cycles, uptake of carbon by land and oceans, and their roles in climate change.**
3. **High-resolution, atmosphere-ocean models for seasonal- to-centennial variability, predictability and regional change.**
4. **High-resolution atmosphere models for understanding "weather extremes" in climate (e.g. Atlantic hurricanes, heat waves and droughts).**

Coupled Chemistry-Aerosol-Climate model

AM3/ CM3

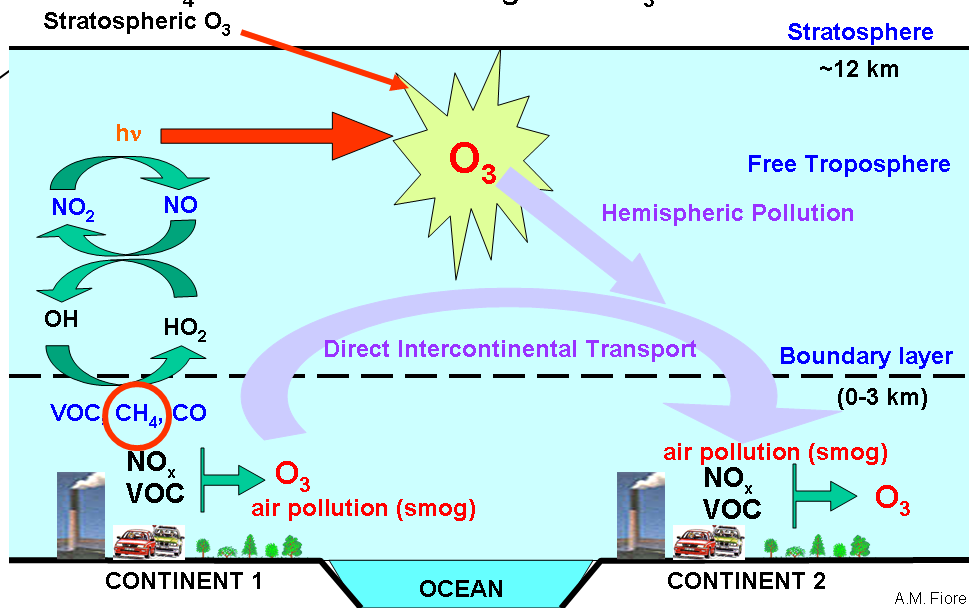


Aerosols and Climate

Global Air Quality and Climate

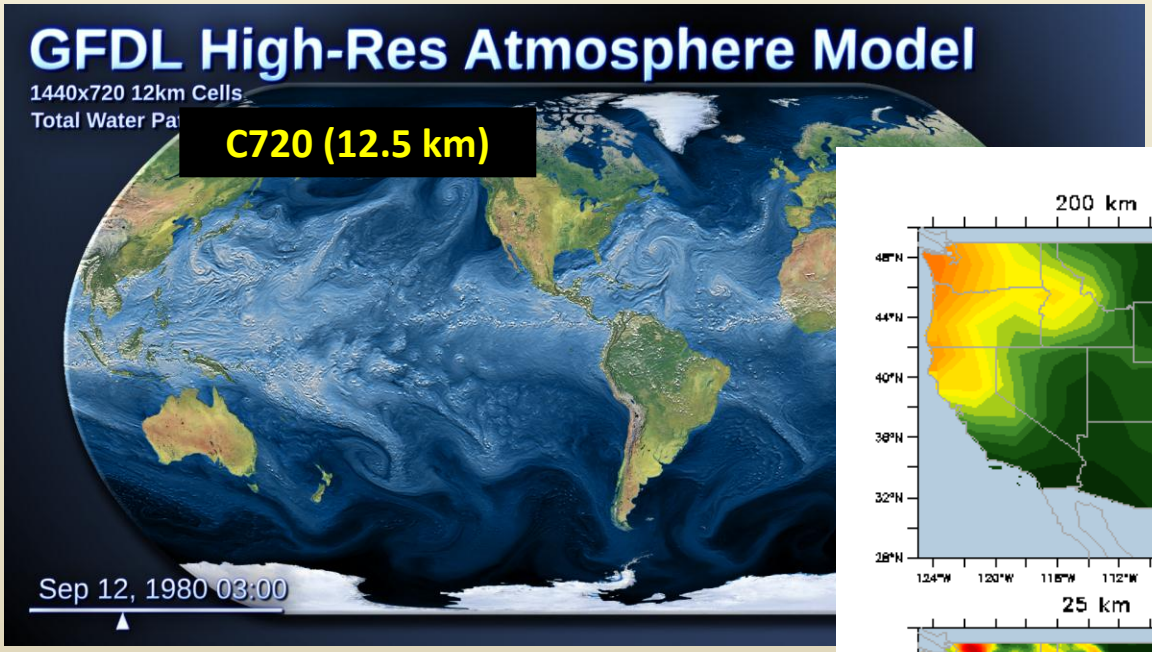
CH_4, O_3 are greenhouse gases

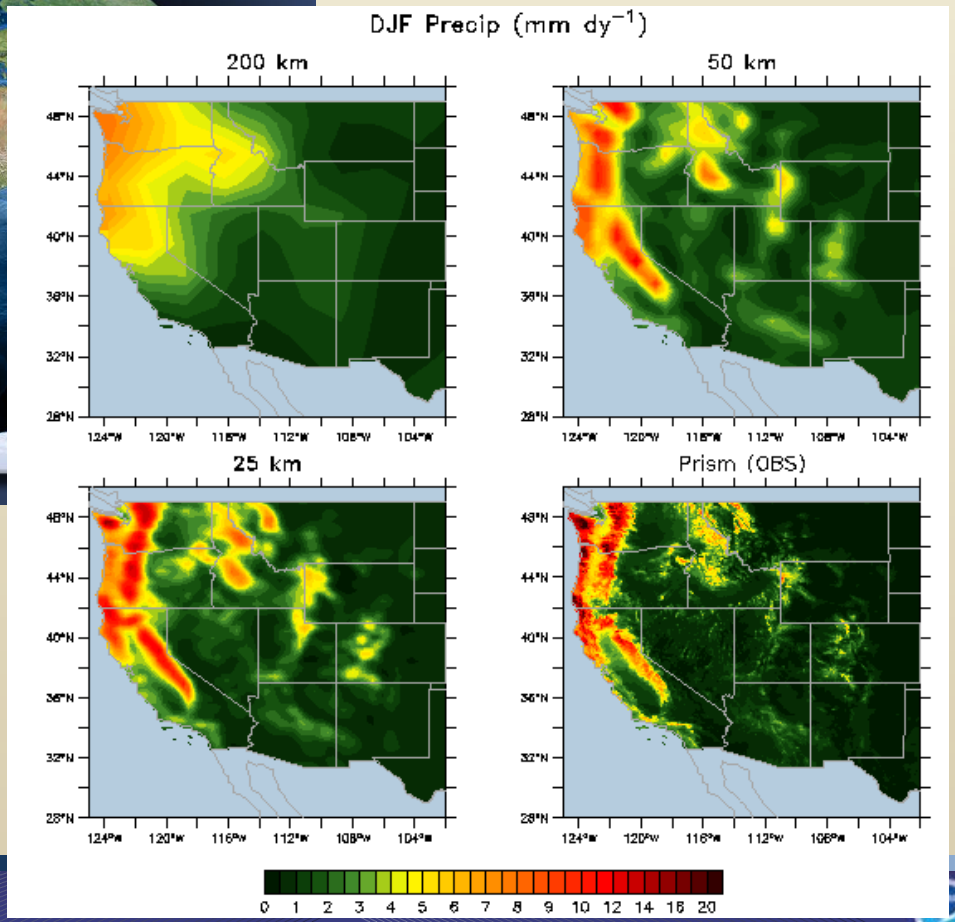
CH_4 contributes to background O_3 in surface air



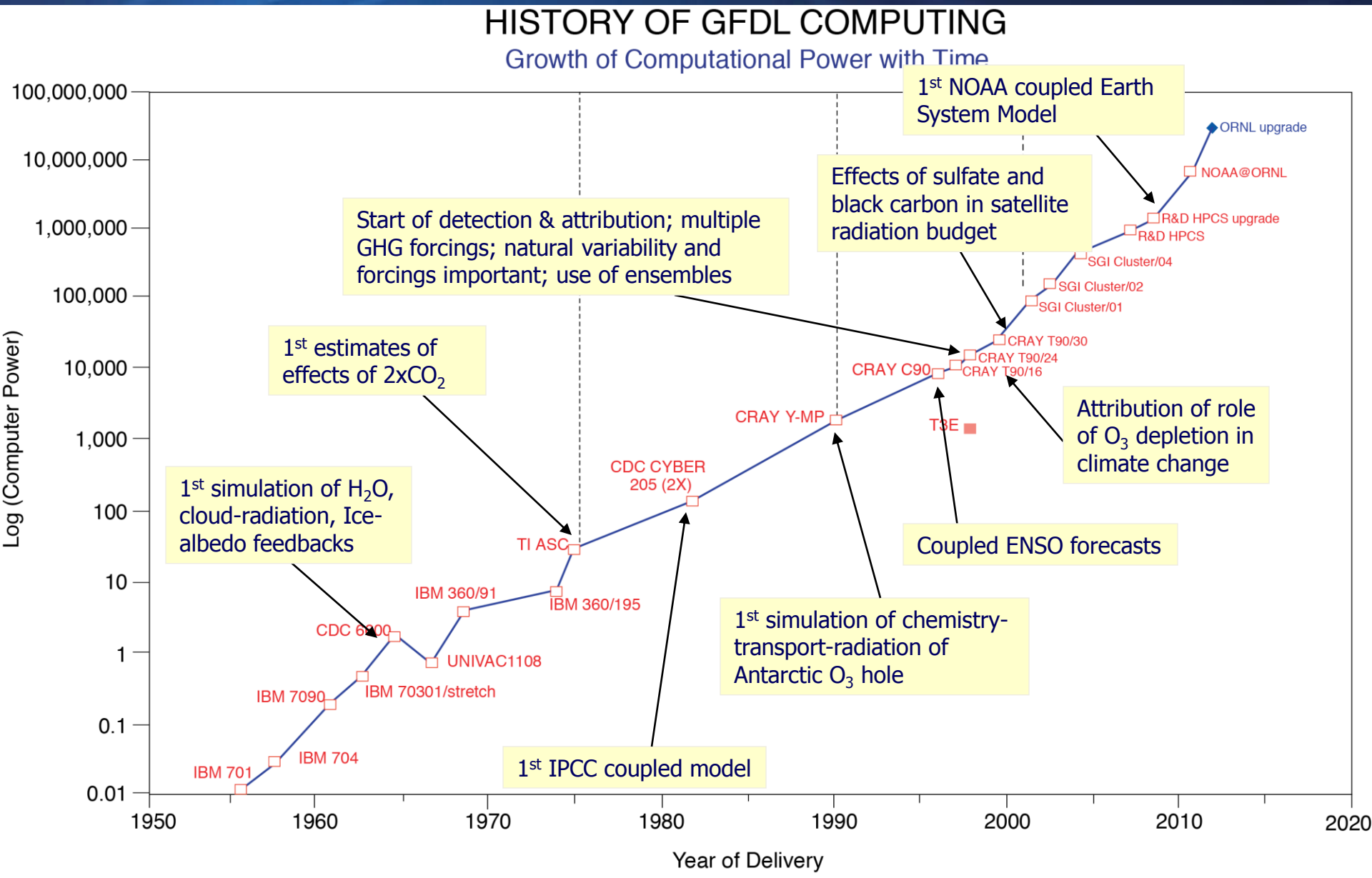
A.M. Fiore

High resolution atmospheric modeling at NOAA/ GFDL





Scientific Advances are Linked to Computer Power



Current Key Scientific Challenges

- Seasonal-to-multi-decadal climate variability and predictability
- Climate feedbacks and sensitivity
- Hydrologic cycle, clouds (including “indirect” effects)
- Chemistry-Aerosol-Climate modeling, and near- and longer-term 21st C and beyond climate change
- Regional climate variations/change.
- Climate extremes. Abrupt climate change.
- Land and ocean biogeochemistry-climate interactions
- Marine ecosystems and climate. Ocean acidification.
- Ice sheet–ice shelf–ocean interactions
- Sea-level rise. Coastal changes.
- Climate impacts, assessments, and engagements

The END